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MANUFACTURING FACT FINDING GUIDE

FINAL DRAFT

5 April 1990

MANUFACTURING FACT FINDING GUIDE
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MANUFACTURING FACT FINDING GUIDE

1. Introduction

Manufacturing Fact Finding (FF) is one of the key elements of hardware production contract proposal evaluations. It is a critical examination of the offeror's cost (labor) estimates relative to the solicitation and the proposed manufacturing approaches and methods which culminates in a Technical Evaluation Report. The Technical Evaluation report addresses the quantitative and qualitative aspects of the proposed direct and support labor estimates and is a major input to, and often the cornerstone for, contract negotiations. The manufacturing fact finding Technical Evaluation Report must therefore stand on its own and cite reasons for its findings sufficiently compelling to prevail during negotiations.

(cont fr p b)

1.1 Purpose

The purpose of this document is to delineate a set of guidelines for fact finding production hardware manufacturing proposals to ensure fact finding is properly, rigorously and consistently performed by BMO. The audience targeted by this document are those individuals called upon to fact find the Manpower Volume of hardware manufacturing proposals. For the fact finding neophyte, it is intended as a primer and guide for the process. For the fact finding veteran, it is intended as a refresher and check list of the fact finding process. It is noted that there is no substitute for an experienced Fact Finder—it is the objective of this guide to help the new Fact Finders quickly gain the requisite experience.

1.2 Scope

This guide is intended for the evaluation of direct and support labor estimates and is therefore limited to fact finding the Manpower Volume of proposals for hardware production contracts. It is not applicable to fact finding of other volumes (i.e., Cost, Technical and Management) or proposal submitted for full scale development or other type contracts.

1.3 Background

The following paragraphs briefly provide background regarding Manufacturing Fact Finding as related to BMO. It is formatted as a series of questions and answers and is intended for the fact finding neophyte.

What Authorizes Fact Finding? Fact finding is authorized by the Federal Acquisition Regulations and implemented by Air Force Regulation (AFR) 75-15, Source Selection Policy and Procedures and the Request for Proposal (RFP).

Why Fact Find? Fact finding is integral to the progression of the Air Force procurement process. Fact finding is conducted to determine whether the offerer's proposed costs are realistic in relation to the solicitation (the RFP) and the technical proposal, and to provide an assessment of the reasonableness of the proposed cost. If the proposal cost is deemed totally unreasonable and/or unfounded, an independent recommendation of what the contract should cost should be prepared and will serve as the basis of contract negotiations with the offeror.

What Triggers Start of Fact Finding? Who Decides What Requires Fact Finding and Why? Formal fact finding is initiated by receipt of the proposal which is immediately subjected to a quick review to determine if it is responsive to, and contains all the information specified by, the RFP. This determination is made by BMO (the project officer with assistance of a Contract Price Analyst) with support from BMD if requested. If the proposal is deemed deficient, the project officer, the Contract Price Analyst, and the contracting officer immediately request remedial submittals, usually the missing data. If the requested data is not furnished, the proposal is rejected. If the proposal is deemed acceptable, fact finding proceeds according to an evaluation plan developed by the project officer and the Contract Price Analyst with inputs from members of the fact finding team. This evaluation plan is prepared following the quick review of the proposal and establishes review responsibilities and schedule milestones. The evaluation plan identifies, based on the quick

review of the proposal, areas to be given special attention or treatment. These special areas may be driven by a number of considerations such as technical/schedule risk, use of new technologies/manufacturing processes, unusual procurement requirements, non-continuous production, or any other special circumstances.

Who Assigns Personnel to Fact Finding? Generally, the project officer assembles and directs the efforts of the fact finding team. The project officer is assisted by a Contract Price Analyst. The composition of the fact finding team varies to suit the nature of the proposal being evaluated and is composed of both technical and non-technical specialists as required to ensure a comprehensive evaluation. Fact finders are usually drawn from BMO/BMD, however when specialties not organic to BMO/BMD are required, resources from other government agencies may be employed.

What is the Procedure for Acquiring the Information Necessary to Perform Fact Finding? The primary source of information is the offeror's proposal. The offerors are directed to prepare and submit a proposal in accordance with a set of Proposal Preparation Instructions (PPI) which is integral to the solicitation. (A typical PPI is shown in APPENDIX II) The fact finding team reviews the proposal to glean the information required to make the necessary assessments. Where aspects of the proposal require clarification, or data provided is inadequate, or contradictory, Requests for Information (RFIs) are issued to the offeror. These RFIs are submitted and processed formally through the contracting officer or informally through verbal communications. Informal queries and responses thereto are documented for the record.

What are the Steps to be Performed in Fact Finding? The fact finding methodology is described in section 4 of this guide. It is a process which entails extracting and evaluating data from the proposal. If the data is not available in the proposal, the data is obtained via RFIs (formally) or verbally (informally) from the offeror. The objective is to evaluate the proposed effort and cost for reasonableness against the solicitation in relation to the offeror's manufacturing and management approach. This data is also evaluated against the offeror's past performances on similar or related manufacturing efforts when possible. Integral to every proposal is the justification of the offeror's estimates. A key element of fact finding is the review and evaluation of these justifications. If the justifications are valid, estimates are accepted. If not, the estimates are rejected and the offeror asked to justify and/or revise the estimates. All rejected parts of the proposal or estimates must be for sound reasons which stand on their own merit and are sufficiently compelling to prevail during negotiations. On occasions, it may be determined that the contractor underestimated the effort required and additional hours in some areas may be recommended.

What is the Expected Outcome of Fact Finding? The fundamental product of fact finding is the Technical Evaluation Report which is used by the government in negotiating with the offeror. At minimum, the Technical Evaluation Report includes:

1. A developed minimum and maximum (probable) position for use in negotiations, and
2. Identification of areas to be negotiated with documentation of the basis for any recommended changes.

Preparation guidelines for the Technical Evaluations Report are included in Section 4 of this guide.

What Feedback is Required to Verify Effectiveness of Fact Finding and to Verify/Update Factors Used? Currently at BMO, a formal library documenting past fact finding efforts is not maintained. However, "personal" libraries are maintained by individual fact finders. These personal libraries often contain data on an offeror's past performance and provide insight into his capabilities and characteristics. To facilitate fact finding and to improve the efficiency/effectiveness of the process, fact finders s[illegible]ld access these "libraries." In fact, a form[illegible] fact finding library should be created and maintained on all manufacturing proposals evaluated. And all fact finders should contribute to and maintain

this library. Separate data bases should be kept for each different contractor. Feedback from the contract negotiations is vital for this library and should be solicited from the negotiators following completion of negotiations to maintain currency and relevancy of the library, and to help fact finders in assessing the impacts of their findings and the effectiveness of their arguments and presentation style. Following each proposal fact finding effort, the factors used to develop the independent cost estimates should be recorded. This library will greatly facilitate evaluation of future proposals and provide bases for the fact finders to argue and justify findings. It will also provide data points on the offeror regarding his performance improvement propensity. The offeror's support labor performance should also be recorded for future reference and to track performance changes.

2. Applicable Documents

AF Regulation 75-15
Contracting and Acquisition Source Selection Policy and Procedures
February 1984

BMO ED 82-3
Engineering Directive for Technical Evaluation Reports
10 June 1982

MIL-STD-1567A
Work Measurement
11 March 1983

DoD 5010.15.1-M
Standardization of Work Measurement
September 1973

3. Terms Defined

This section defines the key parameters and terms commonly used in manufacturing fact finding as conducted by BMO.

Standard/Standard Time. The time which is determined to be necessary for a qualified worker, working at a pace which is ordinarily used under capable supervision and experiencing normal fatigue and delays, to do a defined amount of work of specified quality when following the prescribed method. Fact finders at BMO interchangeably use the terms **Standard** and **Standard Time.**

Touch (Direct) Labor. Labor which alters the composition, condition, configuration, or construction of the product; the cost of which can be identified with and assessed against a particular part, product, or group of parts or products accurately and without undue effort and expense. It is production labor which can be reasonably and consistently related directly to a unit of work being assembled, fabricated, or inspected. It involves work affecting the composition, condition, or production of a product. It includes such functions as machining, welding, fabricating, setup, cleaning, painting, assembling, and on-line inspection or test of production articles. It also includes the labor required to complete the manually-controlled process portion of the automated work cycles.

Standard Time Data is a compilation of all elements that are used for performing a given class of work with normal elemental time values for each element. The data are used as a basis for determining the **Touch Labor Standard Time** on work similar to that from which the data were determined.

Normal Time is the time required by a qualified worker, to perform a task at a normal pace, to complete an element, cycle or operation, using a prescribed method. For manpower estimates contained in proposals submitted to BMO, Normal Time should be based on **Type I Engineered and Type II Touch Labor Standards.** The personal, fatigue and unavoidable delay (PF&D) allowance added to this normal time results in the **Standard Time.**

Standard Time = Normal Time + PF&D

The Touch Labor standards are the foundation of the work measurement system. They represent the baseline from which performance is measured. Consequently, these labor standards do not contain elements of "inefficiency", "realization", or "variances". It is to be noted that labor standards are often modified by "realization factors" (or other inefficiency factors) for purposes of planning, budgeting, scheduling, or estimating. However, only unmodified labor standards are used to deter-mine

normal time associated with any production element, cycle or operation.

Support (Indirect) Labor. Work which is performed rendering services necessary to production, the cost of which cannot be assessed against any part, product, or group of parts or products accurately without undue effort and expense. It includes the labor required to support the operators performing Touch Labor operations. For BMO contracts, the recognized manufacturing support labor functions are:

Shop Supervision
Manufacturing/Production Management
Production Control and Planning
Procurement/Materiel
Manufacturing Engineering
Industrial Engineering
Test Equipment and Tooling Maintenance

It is to be noted that not all of the functions listed are applicable to all manufacturing contracts and there could be other functions not listed which may need to be included and evaluated. The categories included in each proposal are a matter of contractor policy and style.

Personal, Fatigue and Delays (PF & D) PF & D consists of the following allowances:

Personal Allowance is a time value or percentage of time by which normal time is increased to allow for personal needs (for example, getting a drink of water, washing hands, going to the rest room).

Fatigue Allowance is a time value or percent-age of time by which normal time is increased to allow for a decrease in an operator's capacity to produce due to physical or mental fatigue.

Unavoidable Delay Allowance is a time value or percentage of time by which normal time is increased to allow for unavoidable minor delays beyond the control of the operator. Other irregularly occurring or major delays are normally not absorbed by this supplemental allowance, but are charged in accordance with the offeror's overhead charging practices.

Type I Engineered Labor Standards are standards established using a recognized technique such as time study, standard data, a recognized predetermined time system or a combination thereof. The untailored MIL-STD -1567A requires 80% of the **Touch Labor** associated with a labor effort to be covered by the Type I standards. All major contractors per-forming manufacturing work for the DoD are required to establish and maintain **Type I Engineered Labor Standards.**

Type II Labor Standards are the **Touch Labor Standards** that predict the time an element or operation should take based on the best information that is available. This includes all labor not covered by **Type I Engineered Labor Standards.**

Performance Improvement (PI) Curve is a quantitative technique used to predict resource requirements in a manufacturing operation. It is based on historical observations that individuals performing repetitive tasks exhibit an improvement in performance as the task is repeated. Empirical studies of this phenomenon results in three conclusions which serve as the foundation of the current theory and practice:

- The time (touch labor hours) required to perform a task reduces as the task is repeated.
- The amount of improvement decreases as more units are produced.
- The rate of improvement has sufficient consistency to allow its use as a predictive tool.

Figure 1 typically illustrates the PI curve which when plotted on log-log coordinates, is a straight line. The PI curve is discussed in more detail in Section 4 and APPENDIX I of this guide.

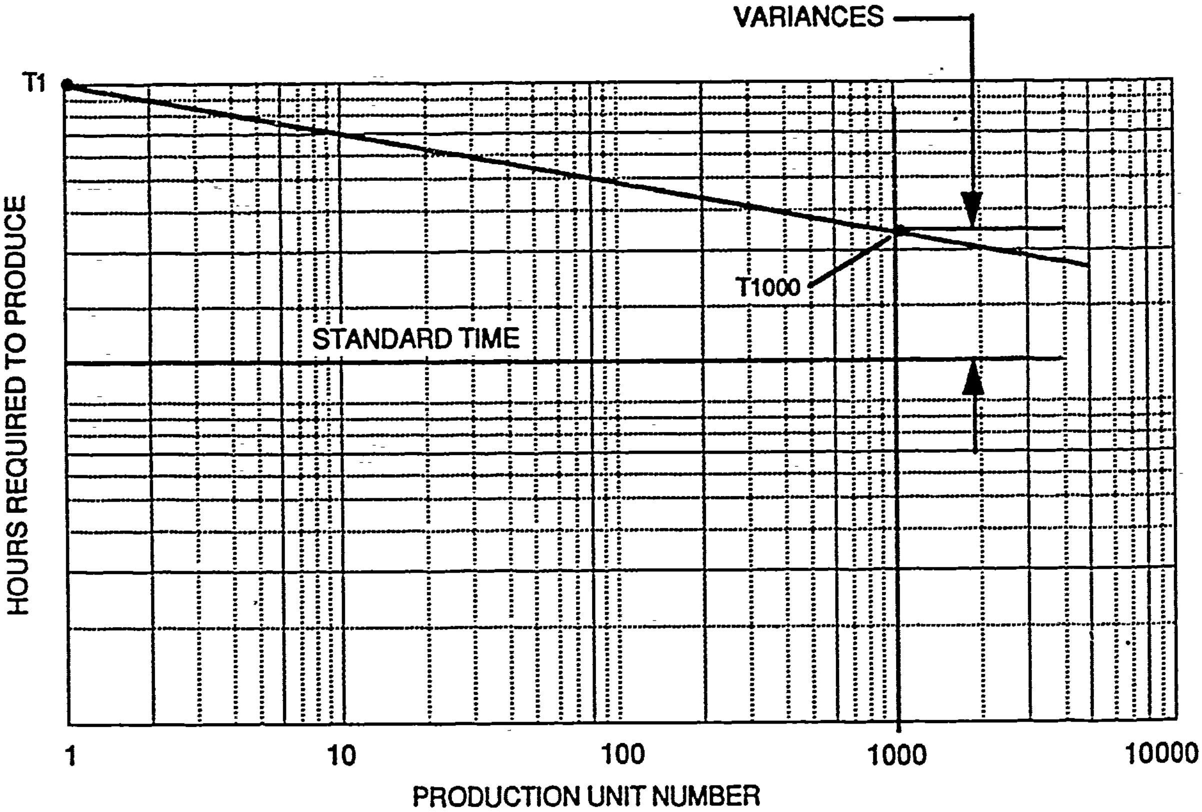

FIGURE 1 TYPICAL PI CURVE EXAMPLE

Slope Factor. This parameter is the slope constant of the performance improvement curve. It is a percentage figure that represents the steepness of the curve. It is also called "the slope of the curve." It is a percentage figure that represents the steepness of the curve. This percentage is represented by the value (in hours or cost) at a doubled production quantity relative to the previous quantity. For example, with a rate of improvement of 90 percent, the unit cost of the 8th unit is 90 percent of the cost of the 4th unit; the unit cost of the 100th unit is 90 percent of the cost of the 50th item, and so forth. It is further described in APPENDIX I.

T1 or First Unit Cost is the theoretical cost (measured in labor hours) of the first production unit. This item is usually determined as a product of the development of the performance improvement curve.

T1000 is the cost (measured in labor hours) of the thousandth unit produced. Typically, for fact finding, it is the estimated cost at a point in the production run at which the variances (non-work) have been diminished to sufficiently low levels that "steady state" production is assumed achieved. It is the point at which performance improvements achieved by the manufacturer have progressed such that the actual touch labor cost (hours) less the allowed variances is equal to the Standard Time. **T1000** is therefore the **Standard Time** modified by the **Realization Factor.** BMO, as a general rule, uses this parameter (and the slope factor) to establish the performance improvement curve.

True Midpoint (TMP) is an artifact used with the PI curve to determine the cost of a production lot. It is the number of production unit which represents the average unit cost of a production lot. It is determined by the equation:

$$\mathbf{TMP} = [\{N \times (1 + b)\}/\{(L + 0.5)^{1+b} - (F - 0.5)^{1+b}\}]^{-1/b}$$

where:

- N = Number of units in the production lot
- F = Production unit number of the first unit in the lot
- L = Production unit number of the last unit in the lot
- b = Slope factor of the performance improvement curve (see APPENDIX I)

Realization Factor is defined by the equation:

Realization Factor = Touch Labor Hours /Standard Time

Where the numerator is the **Touch Labor Hours**, including the allowable variances (non-work), associated with tasks represented by the **Standard Time** in the denominator. The **Realization Factor** is the ratio of the actual **Touch Labor Hours** required to generate a given unit of work compared to the corresponding **Standard Time**. Numerically, it is always greater than 1. It is a measure of overall performance (shop, product line, plant) and is used by offerors in their cost estimates. For BMO production contracts, the generally recognized variances of touch labor from the standard time stem from four elements: Rework, Operator Inefficiency, Shop Inefficiency, and Engineering Changes (see definitions below).

The Realization Factor is a key item of the offeror's cost estimates and is subjected to considerable scrutiny during fact finding. The variance elements of this factor should therefore be fully described and quantified and justified in sufficient detail by the offeror to permit detail assessment by the fact finders.

Variance. The difference between any standard or expected value and an actual value. In the current context, variances are the non-work by which costs (in hours) depart from the real work (Standard Time) required to perform a manufacturing operation. There are four major categories of variances.

Rework: Departures from the standards caused by any corrections of defective work either before, during, or after inspection.

Operator Inefficiency: Departures from the standards attributable to personnel turnover, absenteeism, idle time, etc.

Shop Inefficiencies: Departures from the standards due to short term delays because of material shortages, faulty and broken tools, defective material, etc.

Engineering Changes: Departures from the standards caused by engineering changes after start of production.

Scrap. Residual material resulting from machining or assembly processes, such as machine shavings, unusable lengths of wire, faulty parts, etc.

4.0 The Fact Finding Methodology

Typically, Manufacturing Fact Finding (FF) encompasses two principle efforts; (1) assimilation of the offeror's proposal and cost estimates followed by (2) a technical evaluation of his estimates. Assimilation of the proposal involves extracting data from the offeror's proposal and related submittals supplemented by interchanges with the offeror at FF meetings and through verbal (informal) or written (formal) Requests for Information (RFIs). Technical evaluation involves dissecting, sorting, and evaluating the touch and support labor hours proposed at the component and various ascending levels of assembly such as subassemblies, subsystems, and WBS elements to assess reasonableness of the estimates.

4.1 Phases of Fact Finding

Figure 2 graphically illustrates the FF methodology as typically conducted by BMO. For convenience in this discussion, the methodology is segmented into four phases as shown: I. Pre-Fact Finding; II. Preparation for Fact Finding Meeting; III. Fact Finding Meeting; and IV. Technical Evaluation. The phases often overlap and execution of FF tasks entirely within phases is not crucial nor mandatory. There will be occasions where it will be necessary and prudent to depart from this methodology in response to special needs and conditions. Each of the phases is described in the following.

4.2 Pre-Fact Finding (Phase I)

This phase generally consists of efforts expended in preparation for fact finding such as familiarizing the fact finders with the procurement and background on the potential offeror(s). It often includes supporting the development of the Proposal Preparation Instructions (PPI) of the Request for Proposal (RFP). The PPI specifies how the proposal submittals and cost estimates are to be prepared. Typically, a well prepared PPI concisely and completely specifies the data required for FF (estimated touch and support labor hours and associated costs with justifications) in a form and format unambiguously traceable to WBS elements, sub-systems, assemblies, and components.

A well prepared PPI will significantly reduce the FF team's burden of extracting, interpreting, and evaluating data submitted with the proposal. It is therefore desirable to have a well prepared PPI in the RFP and important to diligently support preparation of the RFP. It is to be noted that the PPI should not require data the offeror is not normally expected to generate in his response to the RFP. The PPI should merely direct the offeror to provide specific sorts of his data to provide insight/information regarding the cost structure and make-up of his proposal. Besides benefiting the FF team, well prepared PPI also benefits the offeror by:

- providing insight to what the FF team will be looking for and evaluating,
- unambiguously directing the offeror how to break-down, sort, summarize and present his labor and cost estimates, and
- allowing the offeror to critically look at his proposal from the FF team's perspective and thus providing him an opportunity to assess reasonableness prior to submittal.

Conversely, a poor (loose) PPI usually forecast difficult FF characterized by:

- proposal submittals which must be carefully and tediously examined to isolate and extract the data required,
- incomplete submittals which do not contain all the data necessary to perform orderly evaluations,
- considerable investment in time and effort with the offeror to extract the data from and decipher the proposal,
- increased subjectivity in the evaluation process, and
- difficult negotiations and potential erosion of BMO/offeror relations.

A loose PPI should therefore be avoided. Fact finders, when given the opportunity, should make every effort to influence the PPI to ensure that the cost estimates are comprehensively prepared and presented in a unambiguous and easy to evaluate fashion. A preferred PPI (generic) related to manufacturing FF is contained in APPENDIX II.

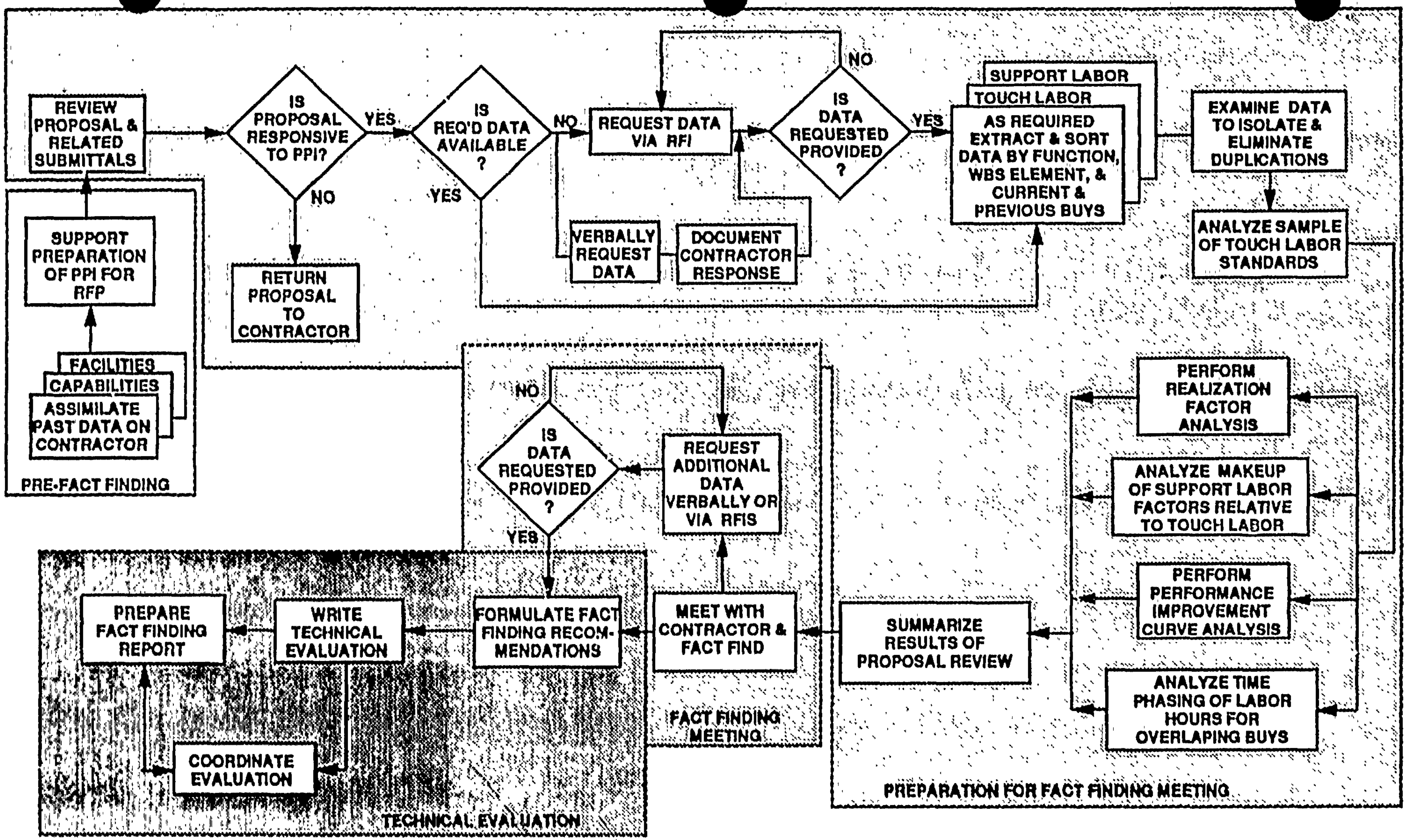

FIGURE 2. FACT FINDING METHODOLOGY (TYPICAL)

4.3 Preparation for FF Meeting (Phase II)

Typically, immediately upon receipt of the proposal, the proposal is reviewed by the project officer and Contract Price analyst to determine that the proposal contains all information required for an orderly technical and cost review. Members of the FF team are often called upon to support this preliminary review to determine what additional data are necessary; and the need for and desired depth of field reviews by AFPRO or DCASPRO. The end result of this preliminary review will be a plan of action which will establish review responsibilities and schedule milestones. In the event that necessary data are missing, the contracting officer should request the additional information immediately, and if not furnished, reject the offeror's proposal.

For the FF team, this is an intensive phase wherein the bulk of the FF effort generally occurs. The primary activities of this phase are illustrated in Figure 2 and consist of extracting, assimilating, and evaluating the labor estimates from the proposal. An independent preliminary analysis of the data is made in this phase. This analysis is compared to the proposed hours to identify discrepancies, FF focus areas, and to prepare for the FF meeting (phase III) with the offeror. These results may be discussed with other members of the fact finding team for purposes of cross-referencing and position assessment.

4.3.1. Data Extraction. This phase is initiated by a general review of the Proposal and associated Basis of Estimates (BOEs) to determine if the labor hour estimates are completely and unambiguously presented. If the proposal is grossly deficient, the proposal may be rejected by the project officer on recommendation of the fact finders. If the pro-posal is only deficient in a few items, appropriate RFIs should be immediately written and submitted through BMO to the offeror for action. To avoid unacceptable or vague responses, the RFIs should be prepared unambiguously with specific information requested and with formatting and structure of the information specified as appropriate. It is important to note that the ability to fact find essentially mirrors the quality of the data available to review and analyze. It is therefore important to ascertain early in the FF process the adequacy and completeness of the offeror's labor estimates and basis of estimates and prepare remedial RFIs as appropriate.

All RFIs should be coordinated with the responsible BMO/AWM officer. It is also prudent to denote "MANUFACTURING" at the top of each RFI because RFIs submitted by other FF disciplines will be submitted and intermingled with the manufacturing RFIs.

Typical suggested generic RFIs can be found in APPENDIX III.

Tabulation of Data. To effectively review and extract data from the proposal, the fact finder needs to determine if, and how, the manufactured item is best compartmented to facilitate evaluation. Very complex items are often divided into manageable pieces generally consisting of subsystems or major subassemblies. Others are very simple and compartmenting provides little additional insight useful to the evaluators. This compartmenting is very discretionary and a function of the experience of the fact finder. Generally, the fact finder uses a level of compartmenting he is comfortable with. There are no rules for compartmenting — whatever makes sense and eases FF can be used. However, it is to be noted (as intuitively obvious) the higher the degree of compartmenting, the better the cost resolution and easier the evaluation.

The major data extraction efforts entail tabulating data as described in the following.

Labor Estimates. While touch labor may only be a small percentage of a production contract, it is used as the basis for nearly all labor estimates. In general, most offerors project their support labor and other associated production labor costs as a percentage of the touch labor. This makes a comprehensive and accurate touch labor analysis essential to the FF process. It is also important to have a good and complete accounting of the associated support labor.

The labor hour estimates are obtained by sorting through the proposal and extracting the proposed labor hours by functions. Use of

technical evaluation forms described in the following paragraph can facilitate this process, particularly if the proposal is poorly organized, disjointed and difficult to sort through. Completion of the technical evaluation forms is optional. Whatever method is used, the total labor hours proposed by functions are extracted, totaled and posted in the first two columns of Table 1 (the balance of the table is filled out later). The manufacturing functions used to sort the labor hours include:

1. Manufacturing Touch Labor

2. Manufacturing Support Labor
   - Shop Supervision
   - Manufacturing/Production Management
   - Production Control
   - Procurement/Materiel
   - Manufacturing Engineering
   - Industrial Engineering
   - Test Equipment and Tooling Maintenance

This particular sort of the labor hours is required to break-down and analyze the support labor hours by functions. Guidelines have been developed over the years for support labor functions as a percentage of touch labor which are representative of reasonably efficient, well managed companies within the aerospace industry. A departure from the support labor guidelines if not adequately justified by the BOEs should trigger additional examination of the proposed support labor hours. Support labor guidelines are contained in APPENDIX IV.

Performance Improvement Curve and Realization Factor (RF) parameters. For each proposal, there exist a minimum set of information which is required to perform analysis of the PI Curve and the RF. These are tabulated in Table 2 and listed below with some relevant annotations:

A. Item. This is the item being manufactured for which a cost estimate is being provided in the proposal and which the fact finder is evaluating. It may be a component, an assembly, a subsystem, or the complete system. This item is a fall-out of the compartmenting made to facilitate evaluation of the proposal as noted previously. It is the entity to which all of the pa-

TABLE I

MANUFACTURING LABOR SUMMARY								
MANUFACTURING FUNCTION	HOURS							
	PROPOSED BUY		RECOMMENDED		DIFFERENCE		% REDUCTION	
	HOURS	% TOUCH LABOR	MINIMUM	PROBABLE	MINIMUM	PROBABLE	MINIMUM	PROBABLE
TOUCH LABOR								
SHOP SUPERVISION								
MFG./PROD. MGMT.								
PROD. CONT & PLAN'G								
PROCUREMENT/MAT'LS								
MFG. ENGINEERING								
INDUST. ENGINEERING								
TEST EQUIP. & MAINT								
TOTAL								

It is to be noted that some of the manufacturing support labor functions listed may not be applicable to a particular manufacturing contract and there could be other functions which need to be included and analyzed; functions should be deleted or added as required to suit a particular contract.

rameters to its right (in Table 2) must apply.

generally specified by the SOW or by the offeror.

TABLE 2

ITEM	LC %	PRIOR QTY	PROP QTY	1ST UNIT	LAST UNIT	TMP	STD HOURS	RF	T 1000	T1	Uc TMP	HOURS (Excluding Scrap)	SCRAP FACTOR	TOTAL HOURS
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

B. LC %. This is the performance improvement rate (r) of the learning curve applicable to the item expressed as a percentage. This parameter is generally specified and justified by the offeror in his proposal. If this parameter or any other parameter listed in this table is judged invalid or unreasonable, a substitute parameter is recommended and justified by the fact finder. An excellent source of improvement curve experience is tabulated in DCAAP 7641.14.

C. Quantity of the item produced by the offeror prior to this contract. This parameter is used to determine the offeror's current position on the PI curve and should include all Full Scale Development (FSD) and production units unless grossly different from the current con-figuration.

D. Quantity of the item to be produced by this contract. This item is

E. This is the sequence number of the first item in the proposed production lot. It is a function of the number of units previously produced (parameter C above) and is numerically equal to parameter C + 1. For example, if C = 50, then E = 50 + 1 = 51.

F. This is the sequence number of the last unit to be produced by this production run. It is numerically equal to parameter E + D. For example, if D = 20 and E = 51, then F = 20 + 51 = 71.

G. TMP or true mid-point. This is the sequence number of the item whose cost is representative of the average unit cost of this production run. It is determined by the formula as described in the discussion of the PI curve found in APPENDIX I.

H. STD hours is the estimated standard time required by an average qualified operator working at nor-

mal speed to produce the line item following the prescribed method. This estimate is provided by the proposal. Reservation noted for item B applies.

I. Realization Factor. This is the factor used by the offeror to modify the standard time (STD hours, parameter H) to account for allowed inefficiencies or variances. The offeror provides justifications for each of the constituents of the realization factor. If the offeror does not adequately justify the realization factor and a different value is deemed more appropriate, the fact finder provides a re-commended value along with the rationale for it.

Note: BMO generally recognizes four variances to the standard hours which comprise the RF (see paragraph on analysis of the Realization Factor). These include rework, operator inefficiencies, shop inefficiencies, and engineering changes.

J. T 1000. This is the unit cost (measured in touch labor hours) of the 1000th unit. It is the total touch labor hours required to produce the line item which is calculated by multiplying the STD hours (item H) by the realization factor (item I).

K. T1. This is the theoretical cost of the first unit (measured in touch labor hours). It is determined by constructing the PI curve. See APPENDIX I for discussion of the PI curve.

L. U_C at the TMP (true mid-point). This is also calculated from the PI curve. The PI curve equation used is found in APPENDIX I. This parameter is the average unit touch labor cost of the line item. The total touch labor cost of the line item will be equal to U_C at the TMP multiplied by proposal quantity (item D). It is to be noted that the TMP is not necessarily an integer and could be any decimal number greater than one, e.g., 25.65.

M. Hours (excluding scrap). This is the total touch labor hours, exclusive of the scrap allowance, required by the line item. It is determined by the product of items D and L. Scrap allowance varies from contractor to contractor and the nature of the items being manufactured. It is therefore best to compute the total touch labor hours required less scrap; and to resolve scrap allowances separately.

N. Scrap factor. Scrap is usually given by the offeror as a factor applied to the total touch labor hours. The factor used should be justified by the offeror. If it is not and a different factor is deemed more appropriate, the fact finder provides an alternative value and his rationale for it.

O. Total hours. This is the total touch labor hours including scrap required by the line item.

Technical Evaluation Reports/Proposal Evaluation Sheets. To facilitate the extraction of the labor hours from the proposal, it is often desirable to use the Technical Evaluation Report and Proposal Evaluation Sheets, Figures 3 & 4 respectively (collectively referred to as **evaluation forms** in the following discussion). These are to be pre-pared and tracked by WBS with task numbers. There is to be only one task number per set of evaluation sheets. However, there may be any number of manufacturing functions, labor categories, etc., within each task number. The proposal should delineate estimated labor hours by manufacturing functions and WBS elements. These optional evaluation forms, if used, are to be diligently prepared because they:

- can greatly facilitate and ease sorting of the data,

TECHNICAL EVALUATION REPORT

TASK NAME ______________________________
Proposal Pages ______________________________
Evaluator Organization ______________________________

TASK NO.	LABOR CATEGORY	CONTRACTOR PROPOSAL HRS.	AF OBJECTIVE MINIMUM	AF OBJECTIVE PROBABLE	DIFFERENCE MINIMUM	DIFFERENCE PROBABLE

Reason for Difference Between Proposal and AF Minimum and Probable Positions

Name/Signature of Evaluator(s) ______________________________ Date: ____________

FIGURE 3. SAMPLE TECHNICAL EVALUATION REPORT SHEET

- can be used as a source for the written rationale to be included in the Technical Evaluation Report, and

- can be used to verify that each manufacturing item in the proposal is accounted for in the FF.

It is to be noted that:

- these evaluation forms sort the proposal by WBS elements,

- these evaluation forms cannot be fully completed until FF occurs because some of the data entry columns are dependent on the results of FF. These individual evaluation forms may be used as a source of data for the completion of the various tables which sort the proposal by manufacturing functions, and

- these evaluation forms are often used to verify that each manufactured item in the proposal is accounted for in the FF. Furthermore, because there are various labor categories, the hours in each labor category are often used by Pricing analysts in the accounting for the ultimate cost difference between proposed, and recommended hours.

Labor Hour Estimates of Major Components and Subassemblies. The proposal should contain data which is or can be sorted for Standard Time against the major components and subassemblies being assembled as shown in Table 3 for the current and (if available) previous buy(s).

Where previous buys exist, this sort provides historical data for comparative purposes. It also facilitates isolation and analysis of changes/trends in Standard Time between buys. This table provides a line-by-line, item-by-item, breakdown of the unit Standard Time as well as the totals, and shows the percent of Type I Standard Time. This data sort provides insight into whether the offeror is technically up to date and how the Standard Times compare between buys. If large changes in the Standard Times, components, and or subassemblies occur between buys it triggers and provides justification for requesting detailed rationale for the changes.

Where previous buys do not exist, this data sort still provides visibility relating to cost of components and subassemblies which can be used to assess reasonableness of the offeror's estimates.

4.3.2 Data Analysis. The foregoing FF tasks extracts and tabulates data from the proposal. The following delineates analyses required of that data as well as other data extracted from the proposal or obtained from the offeror verbally or through RFIs.

It is to be noted that it has been traditional in the Defense Aerospace Industry to utilize actual costs developed during design development and initial (first article) production to predict future touch labor expenditures. However, "actuals" tend to be distorted and inflated as the result of design problems, rework, and scrap early in a program and is not representative of what is achievable. Therefore, "actuals" used as basis of touch labor estimates should be closely examined and not accepted off hand.

The normal purpose for applying performance curves to time standards is to back the standard "up" the curve to determine realized hours at points prior to reaching peak efficiency (or steady state variance).

This is where there is generally philosophical disagreement with contractors despite the fact that the use of standards is mandated by MIL-STD-1567A. The contractors usually base their "estimates" on actuals and project "down" the curve accepting their inefficiencies and we base our estimate on a standard and go up the curve basing it on reasonable variances.

To support the development of an independent cost estimate (paragraph 4.5.1) of the touch labor, three items are required:

1. An analysis of the touch labor based on MIL-STD-1567A Work Measurement Standards,

TABLE 3

MAJOR COMPONENTS AND SUBASSEMBLIES - QUANTITIY AND STANDARD HOURS															
COMPONENTS AND SUBASSEMBLIES	PROPOSED BUY					PREVIOUS BUY A					PROPOSED BUY B				
	QUANTITY		STD HRS		%	QUANTITY		STD HRS		%	QUANTITY		STD HRS		%
	NO./ DEL.	TOT	PER UNIT	TOT/ DEL.	TYPE 1	NO./ DEL.	TOT	PER UNIT	TOT/ DEL.	TYPE 1	NO./ DEL.	TOT	PER UNIT	TOT/ DEL.	TYPE 1
TOTAL															

2. A developed Realization Factor, and
3. A selected PI Curve

From this data and curve, the average unit production cost, in hours, of the production lot can be established. Negotiating from this position is most cost effective and the areas of disagreement are contained in narrow parameters of performance.

Examination of Basis of Estimates. Detailed rationale and justification for each proposed WBS task and labor function should be included in the proposal. These BOEs should be reviewed to ascertain that all estimates are justified and reasonable. Special attention should be devoted to areas indicated through examination of Tables 1, 2 and 3 wherein reasonableness is in doubt or estimates are not consistent with expectations.

Examination of Data For Obvious Errors. Following sort and tabulation of the data into Table 1, 2 and 3, scan the data to isolate and eliminate obvious errors. Errors include instances wherein a cost or cost factor is improperly applied or applied more than once.

Analysis of Realization Factor (RF). The proposal should clearly denote the realization factor used together with a breakdown of how the variance categories contribute to the total RF. The BMO recommended and frequently used variance categories are:

1. Rework: Departures from the standards caused by any corrections of defective work either before, during, or after inspection.

2. Operator Inefficiency: Departures from the standards attributable to personnel turnover, absenteeism, idle time, etc.

3. Shop Inefficiencies: Departures from the standards due to material shortages, faulty and broken tools, defective material, etc.

4. Engineering Changes: Departures from the standards caused by engineering changes.

Some additional variances which often must be considered are yield, precision machining and assembly, and restrictions in assembly. When such is the case adjustments to the Realization Factor are made and justified by the offeror.

A listing of the appropriate variance categories by percent of standard for the proposed RF

should be included with justification for each of the proposed variances. This variance analysis allows examination of how the non-work contributes to the work inefficiencies and to determine opportunities for improvements.

The Realization Factor is generally developed at a position of steady state variance. Steady state is said to occur when the expected variance improvement becomes too small to measure. Since this point takes place far in the future, tooling, fixture design, and similar variances are resolved and the remaining variances are easier to determine and control. The steady state variances can then be broken into the four categories as noted above. The 1000th unit is commonly accepted as the point at which steady state variance occurs.

Performance Improvement Curve Rationale and Justification. The proposed PI curve should be rationalized and justified in the proposal. The factors (slope, standard hours, etc.) used in the construct of the curve should be clearly delineated and justified. A description of the improvement curve, its applicability, and construction is described in APPENDIX I. DCAAP 7641.14 is a useful resource for PI curve rationale.

Scrap Allowances. The scrap allowances used by the offeror should be identified and justified. Scrap merits special attention because it can cause difficulties if not squarely addressed up front. It is often inadvertently allocated at the lowest component levels and again at one or more ascending levels of assembly. Some contractors additionally include it in their RF. This is a clear mis-application of the scrap factor; other inadvertent misapplications are however more subtle and difficult to uncover. It is therefore necessary to not only determine the offeror's scrap rate but to also determine where and how it is accounted for. Examination of the scrap allowances should also be performed to determine validity and to facilitate forecast of potential improvement.

Man Loading. The proposed man loading curves for overlapping production buys should be included in the proposal. This data is examined to assure that all efforts to be performed during this overlapping period are properly allocated to, and expended, against the appropriate buys.

Tooling Costs. Tooling cost (original and replacement cost) to be used for this production buy should be determined. The cost should include material and labor and rationale/justification for the proposed tooling maintenance dollars and hours.

Tooling initially purchased for the program is supplemented and maintained as the program progresses. When specific tooling is identified, together with its use and wearability, the need for either replacement and maintenance is more discernable. When both hours and dollars are called out, ratios to touch labor and initial cost can be developed, assessed, and evaluated for reasonableness.

Labor Standards Evaluation. When standards coverage per MIL-STD-1567A is questionable, establish Table 3 from data in the proposal. If the proposal does not contain the data necessary to complete the table, prepare RFIs as appropriate to obtain the data. This data can be used to evaluate the Standard Time and to calculate and record the data which will be needed to establish the recommended hours for the touch labor time.

In evaluating the Standards, comparison can be made between years on a line-by-line and total basis to detect changes. Also, if the percentage of Type I Standards are not at the level required, appropriate questions can be raised as to why and when the deficiency is to be corrected. Additionally, these revelations can support rationale that questions not only the validity of the Standards but whether time spent in setting required Standards after the fact could have been spent more wisely and more to the government's advantage working on methods improvements, etc. as should be the case to hopefully reduce the Standards and thereby the cost to the government.

4.4 FF Meeting (Phase III)

In this phase, the FF team meets with the offeror. Ideally, this meeting is held at the offeror's facility to permit as the need arises first-hand inspection by the team of the production facilities and processes. The meeting is

generally chaired by the project officer or his designee.

4.4.1 General FF Guidance. Generally at manufacturing FF meetings, the offeror presents his proposal and the proposed labor hours. The actual conduct of the meeting and proposal review vary and are generally a matter of style; different project officers and lead Department of Defense personnel conduct FF differently depending on personal preference, or experience with the specific offeror, or the nature of the production buy. Some conduct a page by page review starting at the beginning of the proposal and sequentially work through each proposal section. Others form separate side meetings which are assigned responsibility of separate sections/disciplines

As the offeror presents his proposal estimated hours and data, the fact finders review these hours, the data used to compute them, the method of computation, and the related rationale provided to establish their validity.

The FF team evaluates the presentations and data presented. Under ideal circumstances, the FF team has had sufficient data (extracted from the proposal and the offeror responses to RFIs) and time to make an assessment of the proposal and labor hours and can formulate and ask questions to gather any further information deemed necessary to examine the offeror's proposal or to substantiate a government position. Questions should be formulated and asked such that the fundamental differences are addressed in such a manner as to either resolve the issue or document a disagreement. The idea is to resolve as many issues as possible at the face to face meeting. At the FF meeting additional RFIs are in order and should be submitted as agreed upon at the onset of the meeting. The offeror's answers/responses are noted, evaluated, and a technical assessment of the proposal is made.

At all times during the meeting, the fact finder should be "up front" with the offeror. The fact finder should share with the offeror, his findings from the review of the proposal. Furthermore, as appropriate, the fact finders should inform the offeror where he stands on proposal estimates, discrepancies, and problems—and, what his expectations are. Generally it is a good idea not to withhold any information from the offeror and avoid "surprising" the offeror. A well informed offeror is in a better position, and likely to be more motivated, to respond to and resolve discrepancies, omissions, and problems. Fact finders need to quickly establish a good working rapport with the offeror and work together to resolve the items identified for fact finding focus during the proposal review. It is to be noted that not all issues, discrepancies will be satisfactorily resolved during the meeting. This is acceptable, as long as both sides fully understand the others position.

At the completion of the FF meeting, the fact finder should have discussed his concerns. He should have in hand the contractor's proposed justification for discrepancies, or commitments which will resolve them. He should certainly leave the FF meeting with sufficient in-formation to substantiate all positions and recommendations which he will make in the Technical Evaluation Report, or with firm commitments by the offeror that the needed information is forthcoming in a timely fashion.

4.5 Technical Evaluation (Phase IV)

4.5.1 Preparation of Independent Cost Estimate. As a fallout of the above data analyses and the fact finding meeting, the fact finder should have a good feel for the cost parameters appropriate for this offeror on this production effort. Recommended adjustments to the manufacturing cost parameters listed in Table 2 are determined and documented by the fact finder. These adjustments take the form of different recommended cost parameters such as performance improvement rate, RF, Standard Time, Scrap factor, etc. Where appropriate, the cost parameters used by the offeror are to be applied and where adjustments are deemed necessary, the fact finder's recommended parameters should be used.

Having established the performance improvement rate r, the Standard Time, and the Realization Factor at the steady state unit, the PI Curve can be developed from which the average unit cost and the total production lot cost can be computed. The Unit Cost Curve Method is used and is discussed in APPENDIX I.

The end objective is to arrive at a cost position consisting of a minimum and maximum recommended estimates in hours. The minimum is representative of the performance achievable by a well managed, motivated and reasonably efficient contractor with standard manufacturing/management practices. The maximum cost is normally the cost representing the upper bound beyond which cost would be unacceptable, unreasonable or indicative of excessive inefficiencies on the part of the offeror.

Generally, the minimum cost is determined from the construction of the PI curve. The PI curve is constructed using the parameters provided by the offerer adjusted as appropriate by the fact finder. In all cases, all adjustments made by the fact finders are documented and include complete justification for the adjustments made.

Factors affecting the maximum cost position are manifest and vary widely. In general, there is no single approach or formula for the development of this position.

4.5.2 Projection of Recommended Hours. Using the independent cost estimate prepared above as basis, recommended hours are entered into Table 1. The recommended hours should include two values: a minimum value and a maximum value. These recommended hours are derived from the cost position arrived at in 4.5.1, however adjustments can be made for reason as long as the basis of the adjustments are sound and well documented. These are provided to the Air Force contract negotiators and must be well substantiated particularly if they depart widely from the offeror's estimates (proposal). The minimum is used as negotiations leverage and the maximum is to denote the recommended high end negotiating position.

4.5.3 Identification of Focus Areas for Negotiations. The results of the independent cost estimate are compared to the offeror's proposal to identify areas of discrepancies. These areas are examined:

- to ensure there are no mistakes in the independent cost estimate,
- to, if possible, isolate the fundamental cause(s) for the discrepancies for attention of the offeror,
- to ascertain that the discrepancies are consistent with the fact finders expectations given his knowledge of the parameters associated with this production effort, and
- to give the project officer a rough idea of the magnitude of the differences between hours proposed and hours recommended by the fact finders.

These areas are coordinated with the project officer to establish the BMO position and as appropriate identified for special focus during negotiations.

4.5.4 Technical Evaluation Report. The Technical Evaluation Report is to be prepared in accordance with the requirements of BMO Engineering Directive 82-3. It is a very important document which must be diligently prepared. To be useful in the negotiations process, the technical report must stand on its own and cite reasons for findings sufficiently compelling to prevail during negotiations. The Technical Evaluation Report is used as a basis for:

a. Further FF with the offeror

b. Development of (1) a minimum and (2) a most probable position for use in the pre-negotiations conference

c. Development of the specific negotiation plan and as a specific guide during negotiations.

APPENDIX I: PERFORMANCE IMPROVEMENT CURVE

APPENDIX I. PERFORMANCE IMPROVEMENT CURVE

Introduction. The learning curve is a production management tool that has been found useful in a number of applications which include cost estimating, production planning, setting cost objectives and cost controls, proposal evaluation, and contract negotiation. Historically, the largest single use has been in cost estimating, the focus of this appendix. Much of the material presented here is patterned after L. M. Matthews' ***Estimating Manufacturing Costs — A Practical Guide for Managers & Estimators,*** McGraw Hill Book Company, 1983

The learning curve or performance improvement curve is an empirically developed relationship between the labor hours required to produce a unit of output and the number of units produced. The labor hours obtained from the learning curve may be the time required to produce a specific unit (unit cost curve a.k.a. Crawford curve) or the cumulative average time per unit through the unit of interest (cumulative average cost curve a.k.a. Wright curve). The primary use of the learning curve is in taking manufacturing labor hours developed as a point estimate (first unit, actual, or standard time) and relating it to a quantity of items to be manufactured.

BSD, like the large majority (92%) of respondents in an Air Force study, uses the unit cost curve for their cost estimating/ evaluating efforts[1]. Therefore, unless noted otherwise, all discussions in this appendix relate to the unit cost curve. The advantages for using the unit cost curve are discused in references 1 and 2 and will not be repeated here. The term most often used by BSD in relating to the unit cost curve is the performance improvement (PI) curve and these are used interchangeably in this discussion. The importance of understanding the basis and application of the PI curve can not be over emphasized. It is a key element of manufacturing fact finding as practiced by BSD and all managers and fact finders should be conversant with it and alert to its applications. The purpose of this appendix is to provide a description of the PI curve and delineate its application to fact finding to better serve the need of users.

Background of the Performance Improvement Curve. T. P. Wright of the Curtiss-Wright corporation is generally credited as the father of the learning curve. An aeronautical engineer, Wright managed the Curtiss-Wright plant in Buffalo, NY. In studying his past actual cost of building airframes, he observed the following phenomenon: With each doubling of the quantity of airframes produced, the cumulative average cost at the doubled quantity bore a fixed and lower relationship to the cumulative average cost at the previously undoubled quantity. Wright published his finding in the February 1936 issue of the ***Journal of Aeronautical Sciences.*** Initially, Wright's article caused no great furor in American manufacturing or management. However, the outbreak of WW II caused a frantic expansion of the airframe industry. Simultaneously, tremendous pressure was exerted on the industry by the government who wanted to know how many airframes can be delivered next month? And the month after? For want of a predictive tool, the industry adopted Wright's learning curve, invested a lot of talent to work on it and refined it, and used it with great authority and effect. During and following WW II, the Air Force collected and studied cost data from airframe manufacturers as more and more air planes were produced. Empirically, these studies confirmed and established:

- The time required to perform a task reduces as the task is repeated.
- The amount of improvement decreases as more units are produced.
- The rate of improvement has sufficient consistency to allow its use as a predictive tool.

Today, use of the performance improvement curve is common place in the airframe industry. While the performance improvement curve has it genesis in the airframe industry, it has been found to be applicable to most manufacturing activities.

Performance Improvement Curve Formula. The phenomenon observed by Wright, *viz.*, as the quantity of an item produced is doubled, the cost decreases at a constant rate, is formulated in the PI curve. It is emphasized that the key operative terms are "doubled" and "rate" — with production of successive units, the cost decrease will be successively smaller but the rate of decrease will be constant. And, the rate of decrease applies to doubled quantities.

This cost-quantity relationship is expressed by the equation

$$C = a(x)^b, \qquad (1)$$

where C_x = Cost of the xth unit

a = Theoretical cost of the first unit

x = The xth unit in the production sequence

b = Slope constant of the PI curve

$= \log r / \log 2 \qquad (2)$

Associated with the PI curve is a parameter called the True Mid Point (TMP) or the algebraic mid point of the production lot. It is defined as the point in each lot at which the estimated production cost or hours on the PI curve equals the average for the entire lot. It is determined by the equation:

$$TMP = [\{N \times (1 + b)\}/\{(L + 0.5)^{1+b} - (F - 0.5)^{1+b}\}]^{-1/b} \qquad (3)$$

where: N = Number of units in the production lot

F = Production unit number of the first unit in the lot

L = Production unit number of the last unit in the lot

b = Slope constant of the PI curve

This parameter is used to determine the total cost of the production run being evaluated.

Performance Improvement Curve Example. To illustrate the foregoing, consider the following example:

UNIT NUMBER	LABOR HOURS REQ'D TO PRODUCE UNIT	REDUCTION IN LABOR HOURS	REDUCTION %
1	1000		
2	900	100	10
4	810	90	10
8	729	81	10
16	656	73	10
32	591	65	10
64	531	60	10
128	478	53	10
256	431	47	10
512	387	44	10
1000	349		

r = Performance improvement rate

= complement of the cost reduction occurring as produced quantities double

This is, of course, a contrived example for illustrative purposes only. In reality, all cost data points rarely fall exactly on the curve. Clearly, in this example, as the quantity doubles, a 10 percent reduction in cost is realized. Thus r, the performance improvement rate, is 90% (100% - 10%).

Mathematically, the slope constant b is determined by equation (2):

$$b = \log r/\log 2$$

$$b = \log 0.90/\log 2 = -0.152$$

Thus, since the first unit cost (measured in labor hours) in this example is 1000, from equation (1):

$$C_X = 1000(x)^{-0.152}$$

and for, say the eighth unit,

$$C_8 = 1000(8)^{-0.152}$$

$$C_8 = 1000(0.729) = 729$$

The TMP for this lot of 1000 is determined from equation (3) and is:

$$TMP = [\{1000 \times (1 - 0.152)\}/\{(1000 + 0.5)^{1-0.152} - (1 - 0.5)^{1-0.152}\}]^{-1/-0.152}$$

$$TMP = [\{1000 \times (0.848)\}/\{(1000.5)^{0.848} - (0.5)^{0.848}\}]^{6.579}$$

$$TMP = 340.62$$

And the average unit cost (hours to produce) of the lot is, from equation (1):

$$C_X = a(x)^b$$

$$C_{avg} = 1000(340.62)^{-0.152}$$

$$C_{avg} = 412.19 \text{ hours}$$

Characteristics of Performance Improvement Curves. Two important characteristics of the performance improvement curve are evident in this example. The first is the rate of change is constant, i.e., 10% in this case, and the change is always downwards if performance improvement is being realized. Therefore, the slope constant b is always negative. The second characteristic is the size of the reductions in hours required to produce the item is decreasing as produced quantities increases. That is to say, as successive units are produced, the reduction in hours becomes successively smaller. The hours of reduction are always positive, though smaller and smaller as production increases. Mathematically, the performance improvement curve is asymptotic. And because the rate of change is constant, when plotted on log-log coordinates, the performance improvement curve is a straight line.

One can readily visualize the utility of the PI curve for estimating the cost of future units when cost data on early production is available. During fact finding, however, early production run data is often not available, i.e., production has not been initiated or not yet authorized. None the less, as will be seen later, the performance improvement curve is still a powerful tool for estimating manufacturing cost.

Figure I-1 graphically illustrates the PI curve. As noted earlier, when plotted on log-log coordinates, the PI curve is a straight line. During proposal evaluations, BMO fact finders routinely construct PI curves not only to facilitate evaluation of the offeror's bid but to develop independent cost estimates (actually these are cost positions: the minimum cost and maximum cost recommendations). To construct the PI curves, several parameters are required. Generally these parameters are contained in the offeror's proposal. Often, however, these parameters are disputed and disallowed by the fact finders. In these situations, the fact finders make adjustments to the parameters and uses them in the construction of the PI curve. Fact finders, of course, must provide justification for their estimates (adjustments). The significant para-meters required to construct a PI curve are:

- Standard Time. This is the time required by an average qualified worker to perform a task at a normal pace, to complete an element, cycle, or operation, using a prescribed method. It is based on the Type I touch labor standards developed and maintained by the contractor as mandated by MIL-STD-1567A.

  It includes allowances for personal, fatigue, and unavoidable delays (PF&D).

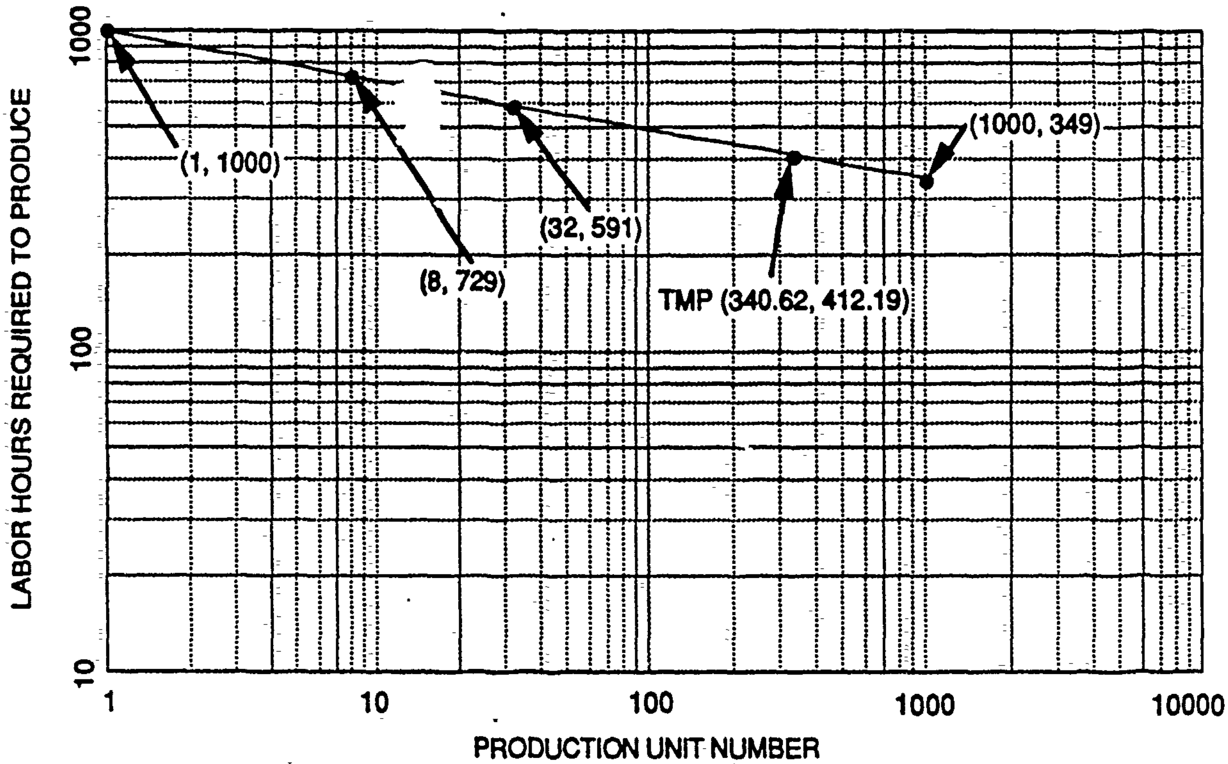

Figure I-1. Example PI Curve (90 % Improvement)

- Performance Improvement Rate. This parameter is a percentage figure that represents the slope (constant rate of improvement) of the curve. It is the complement of the improvement rate being realized. In the example used previously, the cost reduction rate for doubled quantities is 10%. The performance improvement rate is therefore 100% minus 10% or 90% and the resulting curve is said to be a 90% PI curve. Knowing the performance improvement rate, the PI curve slope factor b defined by equation (2) can be determined.

- Realization Factor. This factor is a measure of the overall performance efficiency. It is used to determine the touch labor hours (cost) of the 1000th unit produced as follows:

  Touch Labor Hours = Std Time x (RF)

  The reciprocal of the RF, i.e.,

  1/RF = Efficiency (both management and operator).

Construction of Performance Improvement Curve. Construction of the performance improvement (PI) curve is straight forward provided the parameters described above (which uniquely determine the curve) are available. To construct the curve, one needs to simply apply the realization factor to the standard time and plot this point on log-log coordinates at unit 1000. The curve is then plotted as a straight line through this point with the appropriate slope. To facilitate plotting the curve, equation (2) can be used. For example, suppose the following parameters apply to a particular manufacturing operation for which we want to estimate the total production cost:

RF = 1.32

Performance Improvement Rate = 80%

Standard Time = 100 hours

Production Lot Size = 100 units

Number of First Unit in Lot = (no prior production)

Applying the RF to the standard time determines the actual (touch labor) hours required to

produce the item when changes to the variances have diminished to sufficiently low levels that steady state production is assumed achieved. BSD uses the 1000th unit as the point in production where this occurs. This point is plotted as shown in figure I-2. Using equation (2), the slope constant b is determined as follows.

$$b = \log 0.80/\log 2 = -0.322$$

Which yields the equation for the PI curve

$$C_x = a(x)^{-0.322}$$

which finally yields the following PI curve equation:

$$C_x = 1222\,(X)^{-0.322}$$

Together with the cost of the 1000th unit we have two points from which the PI curve can be constructed. Figure I-2 illustrates the resulting PI curve. From this curve (or equation) the cost of any unit can be determined.

To determine the total cost of producing this lot of 100 units, the TMP must be determined. Using equation (3),

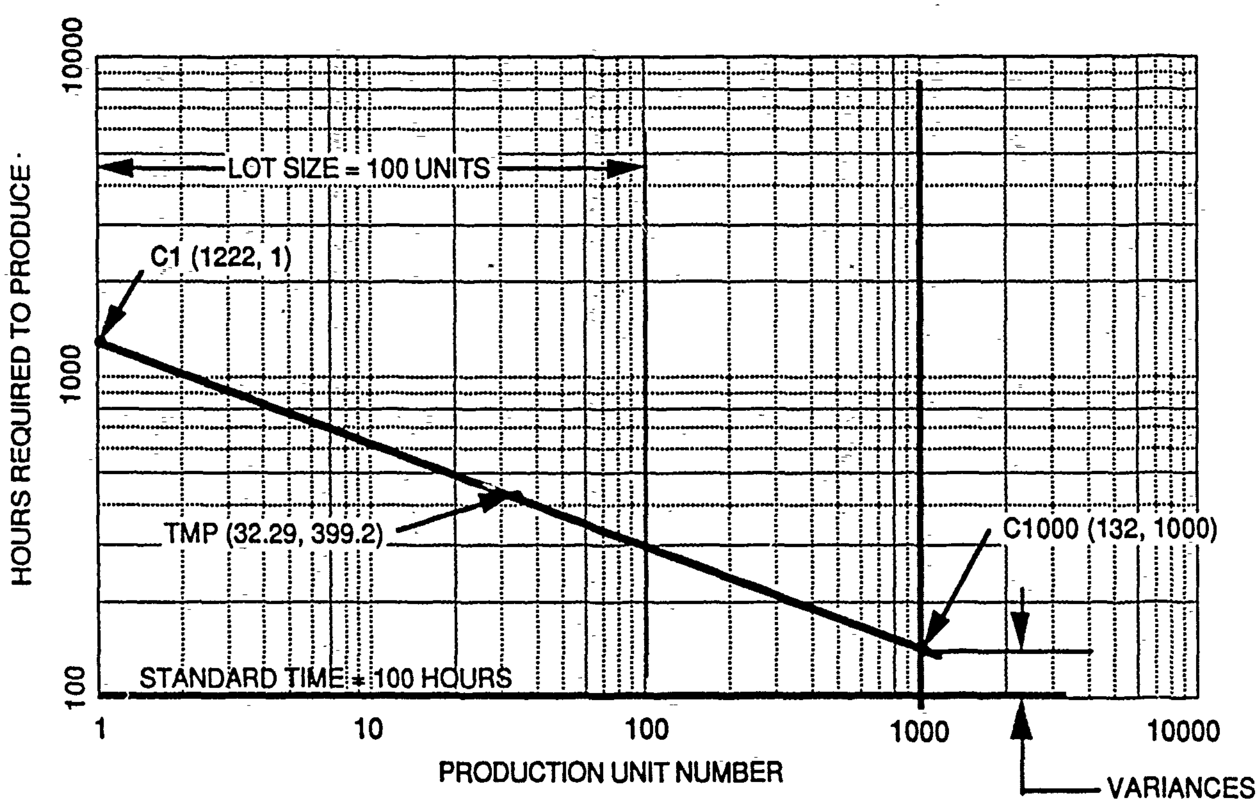

FIGURE I-2 TYPICAL PI CURVE

To determine the theoretical first unit cost (a), we simply use the cost of the 1000th unit in this equation:

$$C_{1000} = a(1000)^{-0.322}$$

$$100 \times 1.32 = a(0.108)$$
$$a = 132/(0.108) = 1222 \text{ hours}$$

$$TMP = [\{100 \times (1 - 0.322)\}/\{(100 + 0.5)^{1-0.322} - (1 - 0.5)^{1-0.322}\}]^{-1/-0.322}$$

$$TMP = [\{100 \times (0.678)\}/\{(100.5)^{0.678} - (0.5)^{0.678}\}]^{3.106}$$

$$TMP = 32.29$$

The average cost of this lot of 100 unit is then equal to:

$$\text{Average cost} = 1222\ (\text{TMP})^{-0.322}$$

$$\text{Average cost} = 1222\ (32.29)^{-0.322}$$

$$\text{Average cost} = 1222\ (0.327)$$

$$\text{Average cost} = 399.16 \text{ hours}$$

And the total estimated cost of this lot of 100 unit is

$$\text{Total estimated cost} = 100 \times \text{Average cost}$$

$$\text{Total estimated cost} = 100 \times 399.16 = 39916 \text{ hours}$$

Additional Characteristics of the PI Curve. By its name, the PI curve focuses attention on performance improvement. Table I-1 lists a sample of elements which have been shown to contribute to performance improvement. From this table it is evident that the total improvement is derived from a combination of personnel learning and management action. While some studies have been conducted, there is no general rule concerning the relative contribution of the specific elements. There is evidence in a study[3] done by Cochran that Touch Labor learning equates to 7 percent on an 85 percent curve. A more reasonable and correct interpretation notes that this is a very small contribution and recognizes that the greatest percentage of learning by far is attributable to management. It is important to recognize the role of management in achieving these improvements and to ensure that appropriate management actions are taken in a timely manner.

Table I-1. Factors Affecting Performance Improvement

WORKER LEARNING
SUPERVISORY LEARNING
REDUCTIONS IN CROWDED WORKSTATIONS
TOOLING IMPROVEMENTS
DESIGN PRODUCTIVITY IMPROVEMENTS
REDUCED ENGINEERING LIAISON
IMPROVED WORK METHODS
IMPROVED PLANNING AND SCHEDULING
INCREASED LOT SIZES
REDUCED ENGINEERING CHANGE ACTIVITY
REDUCTION IN SCRAP AND REWORK
OPERATION SEQUENCING AND SYNCHRONIZATION

Source: DoD Manufacturing Management Handbook, July 1984

The difficulty in developing the PI curve lies in the determination of the parameters (the slope constant, the Standard Time of the 1000th unit, and the realization factor) which uniquely determine a PI curve. These parameters are often embedded in the offeror's proposal and must be isolated and evaluated to determine their validity/appropriateness against the manufacturing effort proposed. If these parameters are deemed not appropriate, they should be disallowed with reasons delineated. The fact finder is then required to select and justify the appropriate parameters to allow development of the independent cost estimate.

There is a wide variability in PI curves. Different contractors have different understanding of improvement curves and therefore different PI curves. Different manufactured items have different PI curves. The studies performed by the Air Force following and

during WW II resulted in the following important findings on the PI curve phenomenon:

- Different performance improvement curves are developed for different airframes.

- When the same airframe is produced by different companies, the companies have different PI curves.

- When the same item is produced by the same company at different plants, those plants have different PI curves.

It is important to recognize that different contractors have different PI curves for different items. And it is folly to apply a PI curve universally to all contractors or items being manufactured. Contractors determine their PI curve(s) by collecting and evaluating cost performance data on individual items or products. Contractors therefore generally have a set of PI curves for different products which they apply when preparing proposals. Although PI curves show a wide variation from contractor to contractor, plant to plant, and product to product, they are generally bound between the 75 and 100% range.

The nature of work and type of manufacturing operations being performed is the major determinant of the slope of the PI curve.

Performance improvement depends on people learning. This learning is predictable. The more complex the task the greater the rate of learning (man paced operations are open to greater rates of learning than machine paced operations). For example, consider machining and assembly. If the machining content of the product's cost is a higher percentage of the item's total cost, the rate of learning declines and the learning curve has a higher percentage value. Conversely, the greater the intensity of hand assembly, the lower the curve percentage. That is to say, the greater the hand assembly content of the operation, the greater the learning potential which yields curves with lower percentage slopes. An 80% slope is representative of higher performance improvement than a 90% curve. Practitioners of the PI curve have used the PI curve within the following ranges in the indicated areas:

Machining	100 - 90%
Fabricating, machine	95 - 80%
Fabricating, hand	90 - 75%
Hand assembly	90 - 60%
Purchased material	100 - 80%

Source: Matthews, Estimating Manufacturing Costs—A Practical Guide for Managers & Estimators

There is no consensus of finding or application. As general guidelines the following represent a rough estimate of performance improvement curve objectives.

Raw Material	95%
Purchased parts	95%
Machining	90%
Fabricating, machine	90%
Fabricating, hand	85%
Assembly	80%
Direct labor (not classified)	87-1/2%
Engineering	90%
Printed circuit-board assembly	85%

Source: Matthews, op cit.

For situations involving a mixture of human assembly and machine processes, the following rates are often used as baselines:

75% Assembly, 25% Machine = 80% Curve

50% Assembly, 50% Machine = 85% Curve

25% Assembly, 75% Machine = 90% Curve

References:

1. R. D. Stewart and R. M. Wyskida, *Cost Estimator's Reference Manual*, John Wiley & Sons, 1987. p. 165.

2. S. S. Liao, "The Learning Curve: Wright's Model vs. Crawford's Model," *Issues in Accounting Education* (Fall 1988). p. 302-315.

3. E. B. Cochran, *Planning Production Costs: Using the Improvement Curve*, Chandler Publishing 1968, p. 587.

APPENDIX II: EXAMPLE PPI

APPENDIX II. RECOMMENDED PROPOSAL PREPARATION INSTRUCTIONS

(b) PROPOSAL PREPARATION INSTRUCTIONS

( ) MANPOWER VOLUME

(i) The instructions for this volume are written to accommodate the most common estimating procedures and requirements. The Government intends to accept offeror's format to the extent that it meets the requirements of this volume. However, to meet our specific needs you may be required to tailor your existing output format. All negative responses to requirements of these instructions must be clearly identified.

(ii) You must submit an original and four (4) copies of this volume to the address set forth in block seven (7) of the Standard Form (SF) 33 and provide two (2) copies each to your cognizant administration and DCAA offices. This volume shall contain, in the format requested, all estimates needed for a complete understanding of your proposed manpower. It must be partitioned into the sections specified in paragraph (C) below.

(A) General Instructions

(a) A separate manpower summary shall be submitted for the basic contract effort and for each option (if any) and for the total contract if options are required. All original forms will be included in the same proposal package and will be so identified on the outside cover.

(b) Additional data submitted to the contracting officer after the initial proposal and up to the certification date shall be completely traceable to the previous proposal and must fully explain the basis for the change. A summary portraying total impact must accompany each change or update.

(c) The Manpower Volume must be traceable to the Cost Volume. HOWEVER, no cost or pricing data shall be presented in the Manpower Volume except that which is necessary for complete understanding of factored labor. All cost resulting from the manpower shown in this volume must be easily identified in the Cost Volume.

(d) Organization and numbering within the Manpower Volume must conform to and be traceable to the Cost Volume. Labor hours and supporting infor-mation must be shown at the fifth level of the PWBS and must be summarized to the next higher CWBS level. The level one summary in this volume must be easily traceable to the Cost Volume.

(e) The instructions for this volume are written with the assumption that all direct labor estimates, including factored labor, are determined by a twelve month fiscal year. Labor estimates shown in this volume must mirror the fiscal periods shown in the Cost Volume. Should any labor factor occur more frequently than annually, then these instructions will be interpreted for the most frequent occurrence. For example, if the offeror's practice is to discretely estimate direct labor on an annual basis and factor a particular labor category on a semi-annual basis, then the proposal must be presented on a semi-annual basis.

(B) Computer Aided Pricing

The preferred method for submitting a proposal under these instructions shall include a computerized pricing model reflecting the estimating system most recently approved for use on government contracts. The pricing model used shall be fully annotated to permit full understanding and use by the government evaluators. Both the model and input must meet the following minimum requirements. The proposal values shall be encoded on a 5 1/4 " 2S2D diskette.

(a) Host machine — Zenith model Z-248 (IBM compatible) with operating capabilities for MS DOS 3.0 or higher.

(b) Host Software — Lotus 1-2-3. Release 2.01

(c) Required pricing model output.

(1) Summaries to be provided in Exhibits 1 through 8 formats.

(2) Changes to the Manpower Volume must result in an automatic adjustment to the Cost Volume summaries.

(3) Mid-point of effort must be an automatic calculation though not necessarily embedded in the summary tables.

(4) Information must be easily printed in Exhibits 1 through 8 format.

(d) The model must be structured so that input at any level of the model will result in an appropriate change to the affected summary. It must also minimize the amount of input preparation time. It must be structured such that it provides an adequate vehicle for use by the Air Force in developing an evaluation position and for comparing the proposal amounts with the Air Force estimates.

(e) A sufficient amount of documentation must be provided so that the model can be easily used by an operator with knowledge and experience limited to the Lotus 1-2-3 system commands.

(C) Organization of the Manpower Volume

The following paragraphs describe the minimum information required to support the proposed manpower. They also specify the section in which the information is to be presented.

(a) Section 1. Summary. This section will contain the manpower summaries at the level which they will be represented in the Cost Volume. These summaries must be presented in the format of Exhibit 1 and must contain the same values as shown in the Cost Volume. The following instructions apply to the data requested in Exhibit 1 format.

(1) "Totals" for in-house labor are to represent a summary of direct labor hours by overhead pool.

(2) "In-house" labor shall be net of standard pricing factors such as scrap, rework, supervision, distributed labor, etc.

(3) "Other" labor shall include any labor generated by pricing factors or otherwise not resulting from discrete estimates.

(4) Entries in the PWBS columns shall be directly traceable to the Technical Volume.

(5) Entires in the "TOTAL" column are row totals from the PWBS columns and shall be directly traceable to the Cost Volume.

(6) The labor categories included in this section must conform to your overhead rate structure.

(b) Section 2. Labor Expenditure Profiles. The offeror shall prepare labor expenditure profiles in the formats shown as Exhibits 2 and 3. Exhibit 2 is an array of total manpower by calendar quarter by overhead pool/major category. The "total" column in Exhibit 2 must be identical to the "TOTAL" column in Exhibit 1. Information presented in Exhibit 3 is similar to that in Exhibit 2 except that the array is by calendar quarter by task. The totals shown in the "TOTAL" column in Exhibit 3 must be identical to the column totals in Exhibit 1.

(c) Section 3. Bases of Estimates (BOE). This section is reserved for the offeror's BOE. Format and organization of the estimates presented in this sections are largely at the discretion of the offeror. There are however, some basic requirements which are mandatory. These are as follows.

(1) A BOE must be provided for all tasks at the lowest indenture required by instructions for the Technical Volume.

(2) Each indenture will constitute a subsection and will be separately tabbed or otherwise segregated from the remaining subsections.

(3) Each subsection will contain, either on the tabbed page or as the first page of the subsection, a summary of the labor hours in that subsection. This summary must be in the format of Exhibit 1. A summary of the lowest indenture will contain the row title column and a "TOTAL"column only.

(4) Each group of subsections of labor falling within the same PWBS category will be summarized at the next higher indenture. The summary, in Exhibit 1 format, will show each task it is summarizing and will provide a "TOTAL" column which will be used in the next higher summary. For example, PWBS task 3.1.7.9.2 would have an Exhibit 1 summary with only the "TOTAL" column. PWBS 3.1.7.9 would be a summary of all PWBS tasks 3.1.7.9.x and would, in Exhibit 1 format, provide the information for the individual tasks of the next lower indenture and would accumulate all 3.1.7.x "TOTAL" columns.

(d) <u>Section 4. Manufacturing Touch Labor (MIL-STD-1567A)</u>. Estimated Direct Manufacturing (Touch) Labor using the most current Engineered Labor Standards in compliance with MIL-STD-1567A and these instructions. As a minimum, all WBS elements which contain touch labor shall be broken out by functional category (e.g., fabrication and assembly, functional test, etc.). These shall further be broken out by Type I and Type II standards (run and setup time) and run quantity for each deliverable unit (see exhibit 5). The touch labor and support estimates shall also be presented in accordance with Exhibits 6 and 7. The contractor's proposal shall also provide a breakout of the Personnel, Fatigue, and Delay (PF&D). The contractor shall identify all unmeasured touch labor efforts. All future improvements which impact on the standard hours (e.g., methods improvement, technical modifications, automation, 5 year capital investment plan, etc.).

Realization elements applied shall also be broken out (see exhibit 5). If a realization factor is estimated by mathematical formula/ equation, this formula must be fully substantiated via statistical sampling method and regression analysis. Work Measurement realization factors used to modify touch labor hours will be based on the contractor's work measurement performance reporting system. Any other modification of these factors for proposal purposes must be fully supported.

Performance Improvement curve parameters used to developed the proposed price shall be identified and fully justified. These parameters shall be tabulated in accordance with exhibit 8. Management goals and trend analysis for each major element of the realization factor and standard hour content of deliverable end items shall be used in projecting proposed touch labor hours.

All work measurement systems data included and used in support of the offer shall be audit verifiable and in accordance with the contractor's Cost Accounting Standards Disclosure Statement. The government shall be entitled to complete access of the contractors work measurement system including any associated data, reports, or studies used by the contractor to support the proposed cost. The terminology used in this paragraph is defined in accordance with MIL-STD-1567A, Work Measurement.

This section will be used solely to explain the derivation of the labor content of the proposed price. It will not be used to provide information intended to be included in the Technical Volume. Each Volume will be evaluated on it's own merits. Information in this volume will not be used in evaluating or understanding the Technical volume except to the extent that total task manpower levels will be provided to the Technical Volume evaluators as required.

MANPOWER EXHIBIT 1

MANPOWER SUMMARY						
BURDEN CENTER	DEPT	PWBS NO.	PWBS NO.	PWBS NO.	PWBS NO.	TOTAL
TOTALS: ENGINEERING MANUFACTURING SUPPORT TOTAL IN-HOUSE TOTALS: SUBCONTRACTOR INTERDIVISIONAL FIELD EFFORT OTHER (specify) TOTAL LABOR						

MANPOWER EXHIBIT 2

LABOR EXPENDITURE PROFILE									
BURDEN CENTER	CALENDAR QUARTER								
	1	2	3	4	5	----	n - 1	n	TOTALS
ENGINEERING									
MANUFACTURING									
SUPPORT									
TOTAL IN-HOUSE									
SUBCONTRACTOR									
INTERDIVISIONAL									
FIELD EFFORT									
OTHER (specify)									
TOTAL LABOR									
PERCENT OF TOTAL									
CUMULATIVE TOTAL									

NOTE: SPECIFY MID-POINT OF EFFORT FOR EACH LABOR CATEGORY SHOWN ABOVE.

MANPOWER EXHIBIT 3

LABOR EXPENDITURE PROFILE									
BURDEN CENTER	CALENDAR QUARTER								
	1	2	3	4	5	----	n - 1	n	TOTALS
PWBS NO. 1									
PWBS NO. 2									
PWBS NO. 3									
- - -									
PWBS NO. n - 1									
PWBS NO. n									
TOTAL LABOR									

NOTE: SPECIFY MID-POINT OF EFFORT FOR EACH TASK SHOWN ABOVE.

MANPOWER EXHIBIT 4

CDRL MANPOWER SUMMARY					
LABOR CATEGORY	CONTRACT DATA ITEM NUMBER				
	CDRL NO.	CDRL NO.	CDRL NO..	CDRL NO..	TOTAL
ENGINEERING					
MANUFACTURING					
SUPPORT					
TOTAL IN-HOUSE					
SUBCONTRACTOR					
INTERDIVISIONAL					
FIELD					
OTHER (specify)					
TOTAL LABOR					

NOTE: COMPLETION OF THIS EXHIBIT IS LIMITED TO CATEGORY I DATA ONLY. COSTS FOR DATA CATEGORIES II AND III WILL BE INCLUDED ON THE COMPLETED DD FORM 1423

MANPOWER EXHIBIT 5

	Deliverable End Items 1 2 3 4 5 - - - - - - - -
— Manufacturing Cost Element	
— Work Center (SHOP)	
— Standard Hours (Type I)	
— Run	
— Set-up	
— Standard Hours (Type II)	
— Run	
— Set-up	
— Run Quantity	
— PF & D Allowance	
— Other Touch Labor Hours	
— Realization Factor	
— 1*	
— 2*	
— 3*	
— Etc.*	
Realization Total:	
Standard Total:	
Total Hours:	

NOTE: All values provided must be substantiated with back-up data
* Contractor identified elements, subject to negotiation between the contractor and AFPRO/SPO

MANPOWER EXHIBIT 6

MANUFACTURING LABOR SUMMARY						
	PROPOSED BUY		PREVIOUS BUY A		PREVIOUS BUY B	
MANUFACTURING FUNCTION	HOURS	PERCENT TOUCH LABOR	NEGOTIATED/ BUDGET HOURS	PERCENT TOUCH LABOR	NEGOTIATED/ BUDGET HOURS	PERCENT TOUCH LABOR
TOUCH LABOR		-		-		-
SHOP SUPERVISION						
MFG/PRODUCTION MGMT						
PROD CONTROL & PLANNING						
PROCUREMENT/MATERIALS						
MFG ENGINEERING						
INDUST ENGINEERING						
TEST EQUIP & TOOL MAINT						
TOTAL		-		-		-

MANPOWER EXHIBIT 7

MANUFACTURING HOURS - TOUCH LABOR							
WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
XXXXX							
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

MANUFACTURING HOURS - SUPPORT LABOR							
WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	SHOP SUPV.						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	PROD.MGMT						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	PROD. CONT.						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

ETC.

MANPOWER EXHIBIT 8

ITEM	LC %	PRIOR QTY	PROP QTY	1ST UNIT	LAST UNIT	TMP	STD HOURS	RF	T 1000	T 1	U c TMP	HOURS (Excluding Scrap)	SCRAP FACTOR	TOTAL HOURS
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O

APPENDIX III: EXAMPLE RFI

APPENDIX III. TYPICAL REQUESTS FOR INFORMATION

The information required to evaluate a proposal is often dispersed throughout the proposal and as a result very difficult to isolate and extract, sort, and interpret. When this situation exists, the proposal may be rejected. More often however, the proposal are marginally acceptable as prepared and only require supplemental information. In these situations, clarifications and supplemental data are requested from the offeror. For minor items such as typos and other simple questions such as "how did you arrive at that figure?", the most expedient method is used. This is most usually a telephone call. If this method proves unsatisfactory or more substantive questions, discrepancies and omissions need to be resolved, formal Requests for Information (RFIs) are used. These RFIs are to be used whenever a documented formal response or contractor position is required for a clear understanding of his proposal. All RFIs should be coordinated and reviewed with the responsible BSD/AWM project officer and are transmitted to the contractor through the Contracting Officer. Contractor response to RFIs are mandatory.

Two kinds of RFIs can be written: generic and specific. Generic RFIs apply to a category or range of data requiring clarification or amplification. Specific RFIs apply to a narrow or singular set of data. Some typical generic RFIs are included below. These typical RFIs are included to serve only as a an example of the kinds of data usually inadequately presented in proposals. These typical RFIs may be tailored to the individual needs of each proposal. RFIs should be submitted immediately during the review process in order to permit the contractor sufficient time to respond.

1. Manufacturing Hours Sorted by Functions. One of the fact finding needs is to analyze the offerer's proposed manufacturing hours by function. If the proposal is not appropriately laid out by function, the following RFI can resolve this problem.

> **"Provide a supplemental Manufacturing Volume with each WBS Task sorted under the following manufacturing functions with reference to the original proposal volume and page number:"**

Manufacturing Touch Labor

- **a. Touch Labor - Fabrication and Assembly**
- **b. Touch Labor - Test**

Manufacturing Support Labor

- **a. Shop Supervision**
- **b. Manufacturing/ Production Management**
- **c. Production Control and Planning and Scheduling**
- **d. Procurement/Material**
- **e. Manufacturing Engineering**
- **f. Industrial Engineering**
- **g. Test Equipment and Tooling Maintenance**

Note: This type of RFI may be inappropriate if a quick response is required. If however, this data is deemed vital to a comprehensive fact finding, it should be requested.

2. **Manufacturing Hours Summary.** BSD has guidelines for support labor functions as a percentage of touch labor developed over the years which is representative of competitive, well managed aerospace companies doing business with BSD over the past twenty years. A sort of the proposed manufacturing hours by WBS sorted by manufacturing functions is desirable and helpful in assessing reasonableness of the proposed effort.

"Provide a summary table (similar to Table III-1) showing proposed hours by WBS element sorted under the manufacturing functions listed. Provide also the corresponding hours for each previous production buy and show these as a percent of the touch labor."

TABLE III - 1

MANUFACTURING LABOR SUMMARY						
MANUFACTURING FUNCTION	PROPOSED BUY		PREVIOUS BUY A		PREVIOUS BUY B	
	HOURS	PERCENT TOUCH LABOR	NEGOTIATED/ BUDGET HOURS	PERCENT TOUCH LABOR	NEGOTIATED/ BUDGET HOURS	PERCENT TOUCH LABOR
TOUCH LABOR		-		-		-
SHOP SUPERVISION						
MFG./PRODUCTION MGMT.						
PROD. CONTROL & PLANNING						
PROCUREMENT/MATERIALS						
MFG. ENGINEERING						
INDUST. ENGINEERING						
TEST EQUIP. & TOOL MAINT.						
TOTAL		-		-		-

3. **Manufacturing Hours by Line Items.** A further breakdown of the sorting of Table III-1 has utility in evaluating the individual support labor categories.

"Provide a further breakdown of the sorting in Table III-1 with a line item, line-by-line sorting and totaling of the functional sorts as shown in Table III-2 for each of the labor functions and related WBS tasks."

TABLE III - 2

MANUFACTURING HOURS - TOUCH LABOR							
WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
XXXXX							
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

MANUFACTURING HOURS - SUPPORT LABOR							
WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	SHOP SUPV.						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	PROD.MGMT						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

WBS NO.	DESCRIPTION	VOLUME/ BOOK	PAGE	LABOR CATEGORY	ORGANIZATION CODE	QUANTITY	HOURS PROPOSED
	PROD. CONT.						
XXXXX							
XXXXX							
XXXXX							
	TOTAL						

ETC.

4. Justification. This is required when the contractor's rationale provides inadequate, vague, or non-existent justification for proposed hours. Example of an inadequate justification: A contractor contends — "This is based on the hours negotiated in the last proposal." This may sound on the surface to be a reasonable basis for the estimate. However, it should be noted that the items typically "negotiated" are the bottom line numbers which are then reallocated by the contractor and usually result in estimates differing from that which was recommended for that particular line item in the last proposal.

Where justification is required, the following RFI is recommended:

> **"Provide detailed rationale and justification for proposed WBS task XX and each associated labor function."**

or

> **"Provide detailed rationale and justification for each proposed WBS task and labor function."**

5. Line by Line, Item by Item Breakdown of Standard Hours. For assessment of whether the contractor is technically current and how the Standards compare between buys, data as defined by Table III-3 is requested. This table provides a line-by-line, item-by-item, breakdown of the Standard as well as the Totals, and shows the percent of Type I Standards. This allows an analysis of whether the offeror is technically up-to-date and employing appropriate production approaches and tooling. It also permits analysis of how the Standards compare between buys by providing historical data. If large changes in Standards, components, and/or assemblies occur between buys it also provides justification for requesting detailed rationale for the changes.

"Provide a Table (similar to Table III-3) showing major components and subassemblies, quantity being manufactured, corresponding proposed standard hours with percentage of Type I Standard Hours. Also, indicate component quantities and total standard hour content per deliverable end item. Further, provide the same data for each previous Production Buy and applicable Development Units.

1. Provide historical data for comparative purposes.

2. Provide detailed rationale and justification for large changes in standard hours between buys."

TABLE III-3

MAJOR COMPONENTS AND SUBASSEMBLIES - QUANTITY AND STANDARD HOURS

	PROPOSED BUY					PREVIOUS BUY A					PROPOSED BUY B				
COMPONENTS	QUANTITY		STD HRS		%	QUANTITY		STD HRS		%	QUANTITY		STD HRS		%
AND	NO./	TOT	PER	TOT/	TYPE	NO./	TOT	PER	TOT/	TYPE	NO./	TOT	PER	TOT/	TYPE
SUBASSEMBLIES	DEL		UNIT	DEL	1	DEL		UNIT	DEL	1	DEL		UNIT	DEL	1
TOTAL															

6. Realization Factor Analysis. When the offerer's realization factors need to be examined, the following RFI requesting breakdown of the realization factor variances is used. This breakdown provides insight on how the non-work (variance) breaks down into the four generally accepted categories. For example, rework and engineering changes are self explanatory. Operator inefficiency is caused by poor performance to Standard by the operator. Shop inefficiency is really management inefficiency and some examples include material shortages, faulty and broken tools, and defective material. The percentage of these variances varies depending on the operation and maturity of the program. It is advantageous for evaluations' sake to include all variances in these four major categories. Some other variables include, yield (scrap), precision machining and assembly, and restrictions in assembly.

We want to see where the numbers came from (Actuals, Departments, Work Centers, etc.) and how they were anived at. Bottom line is to properly assess the variances and outline what things need to be done to increase efficiencies and decrease cost to the government.

> **"To properly assess the Realization Factor (RF) used in the proposal, explain how the variance categories contributed to the total RF, provide a listing of the appropriate variance categories, by percent, for each proposed RF, and provide justification for the proposed variance values. For example:**

1. STANDARD (INCLUDES PF&D)	**100.0%**
2. REWORK	**XX.X%**
3. OPERATOR INEFFICIENCY	**XX.X%**
4. SHOP INEFFICIENCY (MGMT)	**XX.X%**
5. ENGINEERING CHANGES	**XX.X%**
TOTAL	**XXX.X%"**

7. Improvement Curve. Justification for the performance improvement curve used in the proposal must be provided. The performance improvement curve is a function of the kind of work or type of manufacturing being performed. Typically, the PI curve slope is determined in this manner: For labor intensive operations, such as electronic and general assembly, where there are no process controlled functions, a steep slope is used because there is significant opportunities for improvement. Where highly automated non-labor intensive manufacturing such numerically controlled machining is involved, a relatively flat slope is used because there are little opportuninties for improvement. Generally, the typical manufacturing effort consists of a mixture of labor and non-labor intensive operations and a slope somewhere between the two extremes is used.

When such justification is not provided, the following RFI is to be submitted.

> **"Provide detailed rationale and justification for the proposed Performance Improvement Curve Slopes."**

8. Scrap Allowance. Scrap is often difficult to account for and should be confronted directly. It can be applied at the lowest level component and then again accounted for at each ascending level. Some contractors additionally include it in their realization factor. It is necessary to know the contractor's scrap rate (yield) and where it is accounted for in the proposal in order to evaluate its validity and to ascertain that no redundancy is occuring.

> **"Provide detailed rationale and justification for proposed scrap allowances and show how and where they are included in the proposal."**

9. Support Labor. Support labor function estimates are generally made as a percentage of the Touch Labor. The ratio of support to touch labor varies with the cumulative quantity of the production build. And similar to touch labor, support labor efficiency improves with learning and experience, and the inclination of the operation to improvement. Where the cumulative quantity is a small, support labor can run as high as 250% of the touch labor. It is therefore imperative that the rationale used to develop the support labor estimate be evaluated in detail; consequently, the need for detailed rationale from the contractor as in the following RFI.

> **"Provide detailed rationale and justification for the proposed hours for each support labor function. Include improvement factors/curves, historical cost data and relationships to touch labor."**

> **"For those hours estimated by a relationship to touch labor, provide the basis and percentage used, standard hour, historical data or other basis to support the estimate."**

10. ManPower Phasing. Time phased charts yield insight on the manpower ramp-up and ramp-down of each buy and when plotted against each other allow a man loading evaluation of the overlapping buys. Where overlapping buys are programmed, this insight will facilitate assessment of the realism of the proposed support labor estimates.

> **"Provide Time Phased Man Loading Plots for each support manufacturing function for all concurrent programs (e.g., Development/Follow On, Production Buy A, Production Buy B, etc.)"**

11. Tooling. Tooling initially purchased for a program is supplemented and maintained as the program progresses. The cost of this needs to be evaluated. When specific tooling is called-out, its use, wearability, and need for replacement and maintenance is more discernable. When both hours and dollars are called-out, ratios to touch labor and initial cost can be developed, assessed, and evaluated.

> **"Provide the total cost of tooling (original and replacement cost) to be used on the present Buy. Provide the total cost in dollars of proposed tool maintenance for both material and labor. Provide the rationale/justification for the proposed maintenance dollars and hours."**

APPENDIX IV: SUPPORT LABOR FACTORS

1. DoD 5010.15.1-M, Standardization of Work Measurement, September 1973

2. Hartmeyer, Fred C., *Cost Estimating Data Standards for Electronic Manufacturing*, Ronald, New York, 1964

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